DRS-82-03

Why Are Tires Underinflated?

A Survey of Air Pressure Pumps and Tire Maintenance Practices

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Published by:

The Transportation Energy Management Program
The Transportation Technology and Energy Division
Ontario Ministry of Transportation and Communications
Hon. James W. Snow, Minister
H.F. Gilbert, Deputy Minister

Ontario Ministry of Energy
Hon. Robert Welch, Minister
G.R. Thompson, Deputy Minister

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The Editor
Research and Development Branch
Ministry of Transportation and Communications
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

July 1982

ABSTRACT

The present survey was carried out to gauge the accuracy of air pressure pumps and to determine knowledge of tire maintenance practices of the people using the pumps.

118 stations were selected at random from two areas of Metro Toronto. 114 people using the pumps and 39 gas station attendants were interviewed.

Results showed:

- 81% of the pumps were functioning.
- 70% of the pumps were accurate to within ± 2 psi for pressures of 32 and 36 psi.
- Only 5% of the pumps underinflated tires by 4 psi or more.
- The major problems associated with underinflated tires appear to be lack of maintenance and lack of knowledge on the part of the public. As well, gas station attendants appear unaware of proper tire inflation pressures.

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1/ INTRODUCTION

In December 1978, Transport Canada initiated a national tire survey to obtain a representative sample of automobile tire pressures, tire failures and tire maintenance practices. The findings indicated that at least 70% of the tires in the survey were underinflated by approximately 4 psi below car manufacturers' recommended pressures, indicating that there was a problem. To determine the cause of the problem, the present study was conducted by DriveSave, an integral part of the Transportation Energy Management Program (TEMP) established by the Ontario government to improve the fuel economy of Ontario's drivers.

Proper tire inflation is not only important for adequate braking, uniform tread wear and prevention of blowouts, but is also a key element in fuel economy. Tires that are inflated below the maximum cold pressure specifications indicated on the sidewalls increase the rolling resistance, and therefore the fuel expenditure required to keep the car moving. A recent study conducted by TEMP revealed that out of close to 1400 cars, the average tire was underinflated by approximately 56 kPa (8 psi) below tire manufacturers' recommended pressures.

In general, the fuel loss for every 14 kPa (2 psi) of underinflation from tire manufacturers' specifications is about 1%. As a result, the average fuel loss due to tire underinflation is approximately 4%. This is a substantial amount, considering that automobiles use one out of every four barrels of oil consumed in Ontario.

The present study was geared towards identifying the source of the problem of underinflation. Areas that were considered relevant included:

1/ the accuracy of air pressure pumps at service stations;
2/ general knowledge about correct tire pressures; and
3/ general habits of checking and filling tires.

2/ METHOD

2.1/ Survey Sample

A stratified random sample of 118 service stations in Scarborough and North York were surveyed in the study. The sample was comprised of stations having eight different affiliations as well as either self-serve or full service facilities.

At each station the accuracy of air pressure at the pump was checked if possible, the people using the air pumps during the space of a 30 to 60 min period were interviewed and a number of gas station attendants were interviewed as well. The gas station attendant survey was added halfway through the study when it became apparent that many attendants filled tires as part of their duties. In total, 114 motorists and 39 station attendants were interviewed.

2.2/ Selection and Monitoring of Test Gauge

The gauge chosen for the study was a Schrader (Model 8106B Tru-Test Special) calibrated in 1 lb increments from 10 to 60 lbs and in 5 lb increments from 60 to 160 lbs.

Gauge accuracy was tested once a week throughout the survey on a liquid dead weight tester (Ametek, Model TD-100 000W, Type T). Testing was carried out at 10 different pressures between 26 to 47 psi* to calculate the error at any particular pressure within this range.

2.3/ Procedure

Upon arriving at a station, the examiner marked down the station's name, affiliation, type (full service vs. self-serve) and location.

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* This was a "real world" study and Imperial units are used throughout since most air pressure pumps, tire pressure specifications and people surveyed still use them. A metric conversion table is provided in the appendix.

The first step involved bleeding the right rear tire of the examiner's vehicle to 28 psi. The tire was then filled at a pump setting of 41 psi. Pump accuracy was checked by the Schrader guage (as outlined in Section 2.2). The same procedure was repeated for pump settings of 36 psi and 32 psi, respectively. If the pump did not ring to indicate inflation at any of these selected pressures, the tire was bled further to ensure that an accurate pump pressure had been obtained. The three pressures chosen to test the pumps were felt to be representative of, or close to, the pressures used for most passenger vehicle tires.

3/ RESULTS

The results can be divided into 3 separate sections:

1/ accuracy of air pressure at the pumps;

2/ the actual pressure that is used to fill tires compared to sidewall specifications; and

3/ results of the survey questionnaire.

3.1/ Accuracy of Air Pressure at the Pumps

A series of 't' tests (a type of statistical analysis) showed no significant differences between self-serve and full service stations at the three tested pressures. Consequently, the data from self-serve and full service stations were pooled. No data could be obtained at 22 out of the 118 stations surveyed. Of these, eleven had broken or malfunctioning pumps, seven had pumps that consisted of a hose alone with no pressure dial available and four could not be used for various other reasons.

The tested accuracy of the pumps was calculated by a measure defined as Δ D or amount of deviation from any one of the three standard pressures, where Δ D = Pressure setting at the pump minus the reading obtained using the Schrader gauge (i.e., the corrected reading). For example, if the pump pressure was set at 32 psi and the Schrader reading was 34.5 psi, the Schrader error was determined from the weekly graph (e.g., +0.5 psi) and subtracted from the obtained reading (i.e., 34.5 - (+0.5) = 34 psi). Δ D was then calculated as 34 - 32 = +2 psi.

Out of the 118 pumps, 96 or 81% were functioning. Of these, 54 pumps (55%) were within an error of Δ D of $\pm$1 at 32 psi, 56 pumps (58%) were within an error of $\pm$1 at 36 psi and 39 (41%) were within an error of $\pm$1 at 41 psi.

There was no significant difference between the total number of pumps that overinflated or underinflated at 32 and 36 psi. At 41 psi the pumps tended to overinflate (40% overinflating vs. 20% underinflating; $Z = 2.79$, $p < 0.05$). However, comparisons between over and under inflation made at Δ D pressures of $\pm$4 psi showed that a significantly greater

proportion of the pumps overinflated by 4 psi or more as compared to pumps that underinflated by 4 psi or more at pump pressures of 32, 36 and 41 psi ($Z = 1.65$, $p < 0.05$; $Z = 1.58$, $p < 0.057$; $Z = 2.17$, $p < 0.02$ respectively). Only approximately 5% of the pumps underinflated at pressures of 4 psi or more in comparison to 12% or more of the pumps which overinflated by 4 psi or more.

In summary, slightly more than half of the station pumps surveyed provided air pressure to within a ±1 psi accuracy at the two pressures closest to those specified by tire manufacturers for tires in general use on passenger cars. About seven out of ten were accurate to within ±2 psi. At 41 psi, 41% were accurate to within ±1 psi and 48% were accurate to within ±2 psi. This relatively greater inaccuracy at 41 psi is due to an increased shift in the numbers of pumps that overinflate.

Inspection of the data showed that errors of underinflation are confined to a narrower range (between 4 and 5 psi) than errors of overinflation (between 4 psi and 14 psi). As well, a significantly small proportion (5%) of the pumps underinflated by 4 psi or more than overinflated by +4 psi or more (12%). This is an important finding in that it underlines the fact that serious underinflation (i.e., 4 psi or more) is confined to only a small number of pumps. The figure of 4 psi is used as a standard because most people already underinflate by 3 to 5 psi below sidewall pressures (discussed next in the results), and as underinflation reaches 8 psi below tire manufacturers' recommended pressures, the danger of blowout increases.

3.2/ Tire Pressure Used vs. Sidewall Specifications

Of the 114 people surveyed, tire sidewall specifications were obtained from 108 vehicles. Five tires did not have any specifications marked on the sidewall.

Customers at the air pressure pumps were asked the source of their information on the tire pressure they used.

The majority (44%) said they got the information from their car manual; 19% said they used sidewall pressures. The remainder got the information from the dealer (10%), door jambs (9%), friends or relatives (10%) and service station attendants (7%).

Despite the diverse sources of information for tire pressure it was found that motorists tend to fill their tires to an average pressure of 30 psi no matter what the specification on the sidewall. This same trend is evident regardless of how tire pressure information was obtained. One interesting note was that even those people who indicated they were using sidewall pressures were underinflating by an average of 2.4 psi. Thus it is unclear which (or whose) sidewalls customers were referring to, or even if they understood how to read the rated pressure on the sidewalls.

3.3/ Survey Data

3.3.1/ General Public

The survey questionnaire was used to determine the extent to which the general public was aware of correct air pressures and the problems of underinflation. Just over half the people surveyed (57%) owned a tire gauge, but only 14% had checked their tires with the gauge before coming to the station; 48% made a visual inspection; 11% filled their tires on a regular basis; 7% had a leak in one of their tires and 7% said they knew their tires were underinflated by the feel of the ride.

In general, when asked what air pressure they would use if they travelled 10 miles or more to a station, three out of four people said they would set the pump at the recommended level, 14% said they would set the pump at less and 7% would set the pump at more than the recommended level. Only 3.5% said they would set the pump 4 psi higher than the recommended level. In terms of checking and filling their tires, 60% of respondents had checked their tires and 67% had filled their tires three times or less in the last six months.

Most people seemed to be aware of the effects of underinflation: 78% stated that underinflation would increase tread wear, 85% said it would decrease fuel economy and 74% maintained it would increase the risk of

blowout. About 50% of the respondents were uncertain whether ride comfort, wear on wheel rims, or carburettor efficiency would be affected by underinflation, indicating that people were unsure about these last three items, when compared to the first three.

In addition, a comparison of people who owned gauges and those who did not showed that there were no significant differences between the two groups when it came to knowledgeability about tire inflation.

In summary, the majority of surveyed people were aware of the more important aspects of underinflation in terms of fuel economy, tread wear and chances of a blowout.

However, 75% of the sample were unaware of the difference between hot and cold tire pressures and stated that they would put the air pressure pump at the recommended level even after 10 miles of travel. Only 3.5% knew that the air pressure pumps should be set 4 psi higher. This is further reflected by the fact that only 14% had checked their tires with a gauge before coming to the station.

Therefore, although the general public in the sample appeared familiar with the consequences of underinflation, they were not aware of the more specific aspects relating to tire inflation and hot and cold tire pressures. As well, those people who owned tire gauges did not know any more about tire pressures than people who did not, and generally did not seem to use their gauges.

3.3.2/ Gas Station Attendants

Gas station attendants were surveyed to determine the extent to which they were aware of correct air pressures and the problems connected with underinflation. All 39 station attendants surveyed said they helped people fill their tires and had their own tire gauges: 48% had a Schrader, 24% had a Dill (Eaton-Yale), 14% had a Snap-on, 10% had a PCL and 3% had an Atlas gauge.

A little over half the attendants (54%) seemed unaware of the difference between hot and cold tires and stated they would use normal air pressure even after 10 miles of travel; close to 36% said they would use less,

close to 8% said they would use more and only 2.5% indicated a setting of 4 psi (28 kPa) higher than usual pressures.

The majority of station attendants were aware of the effects of underinflation: 67% said it increased tread wear, 85% said it decreased fuel economy, 64% reported increased risk of blowout, and 62% maintained that it increased ride comfort.

In summary, one out of four attendants used sidewall specifications when filling tires. The remaining attendants used a variety of other means. However, a little over half (54%) of the attendants seemed unaware of any differences between hot and cold tires while another 36% said a hot tire should have less air in it. Therefore, in the present sample, 75% of the attendants were using pressures other than sidewall to fill tires and 90% were confused about hot and cold pressure differences.

3.3.3/ Gas Station Attendants vs. The General Public

Z score tests based on proportions were used to compare responses of gas station attendants with those of the general public.

The two groups did not differ significantly in comparing the proportion of people of each group who used sidewalls or door jambs to determine air pressure pump settings. However, in general, the greatest number of attendants (other than those who used sidewall pressures) seemed to use some general rule of thumb based on type of tire, size of tire and/or size of car to determine pump settings (38%) while the public referred to their car manual (43%).

There were no sigrificant differences between the two groups when general knowledge about aspects of underinflation was compared. But a significantly greater proportion of attendants felt that hot tires should be filled below cold tire specifications ($Z = 2.95$, $p < 0.1$) while a significantly greater proportion of the public felt that hot and cold tire pressures should be equivalent ($Z = 2.75$, $p < 0.1$).

In summary, both gas station attendants and the general public appear on the average to be correctly aware of the consequences of underinflation.

However, both groups appear confused as to the difference between hot and cold tire pressures and the majority in each group advocates equivalent pump settings for both hot and cold tires. In addition, while a significantly greater proportion of the public than gas station attendants specify equivalent tire pressures for both hot and cold tires, a significantly greater proportion of attendants than the public specify underinflating a hot tire. Therefore those attendants who are aware of hot vs. cold tire differences don't understand how those differences affect tire pressure.

4/ DISCUSSION

The present study showed that serious underinflation, i.e., underinflation of 4 psi or more, is caused by only 5% of the pumps that were tested. Over half the stations were accurate to within 1 psi and about 70% were accurate to within 2 psi at pressures rated for, or close to, those used in most passenger car tires (32 and 36 psi). At 41 psi, 41% were accurate to within 1 psi and 48% were accurate to within 2 psi. The lower accuracy at 41 psi reflects a significant shift towards overinflation. At this pressure 40% of the pumps overinflated compared to 20% that underinflated, suggesting that overinflation errors increase with increasing pressure.

There were no significant differences between the total number of pumps that overinflated or underinflated at the two lower pressures. However, underinflation was confined to a narrower range (between 2 and 5 psi) than overinflation (between 2 and 14 psi) at all three tested pressures. As a result, a significantly greater number of pumps overinflated by 4 psi or more than underinflated by 4 psi or less.

These results show that one out of five drivers who fill their tires at gas stations, at any one of the three tested pressures, will be underinflating to a certain extent, depending on the particular pump. On the other hand, one in five drivers will also overinflate their tires if they use pump pressures of 32 or 36 psi and two out of five will overinflate at a pump pressure of 41 psi. Therefore, in general terms, the average effect of the pumps would appear to be a tendency towards zero error at lower pressures and towards overinflation at higher pressures.

In terms of the present study, these results mean that air pressure pump accuracy is only a very small part of the problem of underinflated tires. Since, from a recent study, the average underinflation was found to be close to 8 psi below sidewall pressure specifications, motorists themselves seem to contribute to the problem to a large extent.

Only 19% of the drivers who filled their tires at the air pumps indicated that they used sidewall pressures. The rest obtained their information from other sources such as their car manual, door jambs, friends or

relatives. A comparison of the actual pressure that was used to fill tires vs. the sidewall specifications showed that the average tire was filled to around 30 psi regardless of either sidewall specification or how tire pressure information was obtained. This resulted in greater underinflation with increasing sidewall pressure specifications: tires rated at 32 psi tended to be underinflated by 2.5 psi, while tires rated at 36 psi were underinflated by 4.5 psi.

The tendency to underinflate was compounded by the fact that a majority of the respondents (60%) checked their tires three times or less in six months while 67% filled their tires three times or less in that period. These results are not surprising considering that 66% of the sample stated that they only filled their tires as a result of a visual inspection, feel of the ride or some other highly subjective measure. Only 14% of the sample actually checked their tires with a gauge, in spite of the fact that over half the respondents said they owned one. In addition, although the majority were aware of the effects of underinflation on tires, three out of four people were not aware of the differences between hot and cold pressures and indicated that no pressure compensation had to be made for hot tires.

There are two additional points that can be made with respect to the number of times that people check and/or fill their tires. The first is that the people surveyed in the present study were already at the air pumps and therefore may actually fill their tires more often than the driving population in general. The second point is that the rate of tire deflation and what factors affect it (e.g., tire type, condition of tire rim interface, etc.) in a representative sample of cars is unknown and needs to be addressed in a future study.

Since many people get their tires filled by station attendants, a small sample of attendants were surveyed to determine how their knowledge compared to that of the general public. Like the general public, most were aware of the effects of underinflation on tires and tire wear and a little over half (54%) considered hot and cold tire pressure to be equivalent. However, unlike the general public, over a third believed that lower pressures than normal should be used to compensate for hot tires.

In conclusion, only one out of five pumps underinflate by 2 psi or more and only one out of twenty underinflate by 4 psi or more. So although pump accuracy is questionable, they cannot be blamed entirely for tire underinflation.

Other major factors contributing to underinflation include a tendency on the part of motorists to fill tires to an average pressure of 30 psi regardless of sidewall specifications, long periods between tire fills, lack of information on the differences between hot and cold tire pressures and confusion on the part of gas station attendants as to these differences as well. The results suggest that a more intensive program of educating the public about proper tire pressures could correct and perhaps alleviate a good deal of the underinflation found in tires on present day passenger vehicles. The program could include specific information on tire pressure and the differences between hot and cold tires, the best times to check and fill tires, as well as what underinflation means to fuel economy.

APPENDIX/ METRIC TIRE PRESSURE CONVERSION CHART

psi	kPa	psi	kPa
4	28	26	179
6	41	28	193
8	55	30	207
10	69	32	221
12	83	36	248
14	97	38	262
16	110	40	276
18	124	45	310
20	138	50	345
22	152	60	414
24	165	65	448

1 psi = 6.89 kPa